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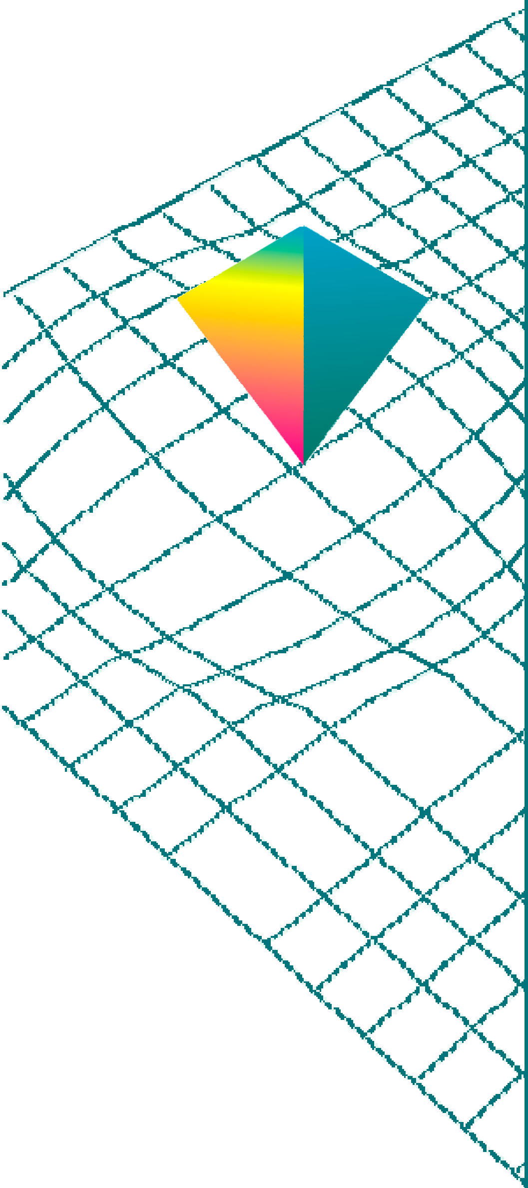

50. Internationales Wissenschaftliches Kolloquium

September, 19-23, 2005

Maschinenbau von Makro bis Nano /

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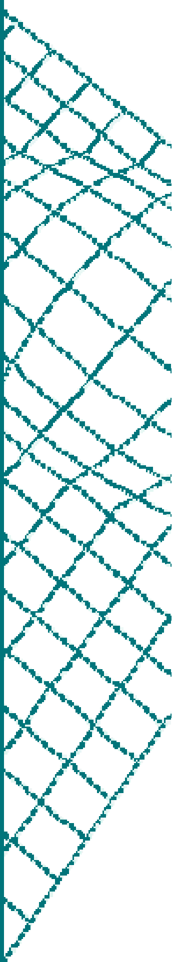

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50. Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
19.-23. September 2005

C. Gießler / J. Steigenberger / K. Zimmermann

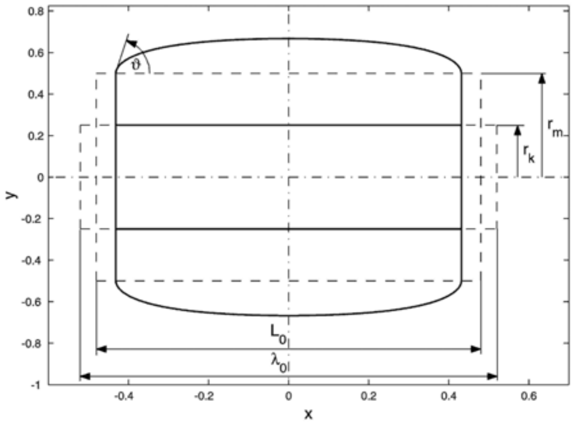
Analytical modelling and numerical analysis for designing an instrument channel in a mobile probe

ABSTRACT

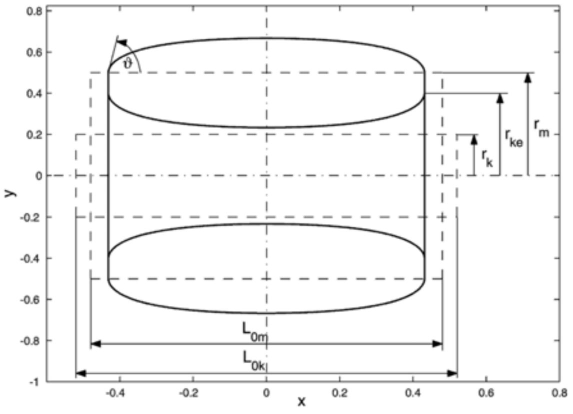
Two models describing the deformation of a cylindrical probe segment under the influence of an external axial actor force are presented. Motivation is the development of a probe moving like an inchworm and being able to transport instruments. The equations describing the segment deformation in the state of equilibrium derived from D'Alembert's principle. Numerical studies of model 1 analyse the segment deformation by variation of characteristic parameters.

MODELS

The outer segment membran of both models is meridionally inextensible and latitudinally the membran is homogeneously Hooke. The boundaries of the instrument channel and the outer membran are both mounted in a conjoint annulus. Apart from the closure of the segment volume they provide an acitve surface for the actor. The positive inner pressure of the filled segment leads to a parabolic segement shape. The instrument channel of model 1 behaves like a pressure/tension spring due to radialsymmetric stiffeners. In model 2, the membran of instrument channel has the same properties as the outer segment membran. This kind of membran can only absorb normal stress and is therefore enlarged on its borders.



Cross section area of model 1



Cross section area of model 2

CHARACTERISTIC EQUATIONS / NUMERICAL RESULTS

Result of the modelling is a fourth order system of differential equation $s \rightarrow (\upsilon, y, x, z)(s)$ with the state variables volume $z(s)$ and coordinates $\upsilon(s)$, $x(s)$ und $y(s)$:

$$\upsilon = \frac{\left[-2py + \left(y/r_m - 1\right)\cos\upsilon\right]\cos\upsilon}{p\left(y^2 - r_k^2\right) + c\left(2x_1 - \lambda_0\right) - f}$$

$$y' = \sin\upsilon$$

$$x' = \cos\upsilon$$

$$z' = 2\pi\left(y^2 - r_k^2\right)\cos\upsilon$$

$$\upsilon(0) = 0,\ y(0.5) = r_m,\ x(0) = 0,\ z(0) = 0$$

The numerical analysis of this boundary value problem is done by the means of shooting procedures. The stiffness of the segments is mainly influenced by the stiffness of the channel c and the filling volume. In contrast, the original length of the channel λ_0 is affecting the working point. The ration between the inner and outer radius r_k/r_m of the annulus is neither influencing the stiffness nor the working point.

Model 2 is described by an seventh order system of differential equations $s \rightarrow (\upsilon_m, y_m, x_m, \upsilon_k, y_k, x_k, z)(s)$ with the state variables volume $z(s)$ and coordinates of the outer $\upsilon_m(s)$, $x_m(s)$ and $y_m(s)$ as well as the coordinates of the instrument channel $\upsilon_k(s)$, $x_k(s)$ und $y_k(s)$.

PERSPECTIVE:

A numerical analysis of Model 2 and an evaluated comparison with the results of model 1 as well as model experiments is essential. To meet the optimal working point proper segment parameters have to be gained by parameter search procedures or methods of the optimal control.

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